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THE EFFECT OF INDUSTRIAL ARTS ON MATHEMATICS ACHIEVEMENT

by



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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled The Effect of Industrial Arts on Mathematics Achievement submitted by Yuan Hsiung Liu in partial fulfilment of the requirements for the degree of Master of Education.

Date *July 29, 1970*

ABSTRACT

The purpose of this study was to examine part of a particular objective of an industrial arts program. The objective was "To provide an environment where students can reinforce and apply the academic disciplines." This study attempted to measure the effect of taking industrial arts on a learner's achievement in grade nine mathematics in Edmonton during the academic year 1969-70.

The subjects of this particular study were selected from grade nine girls attending four separate junior high schools in Edmonton. The sample consisted of a treatment group (N=34) and a non-treatment group (N=78). The students in the treatment group were enrolled in an industrial arts course for at least one academic year during their junior high school education, while the students in the non-treatment group were never exposed to this course.

Achievement in mathematics was measured in terms of the grade nine mathematics departmental examination in Edmonton. This examination was composed of three objectives: (a) knowledge, (b) comprehension, and (c) application, analysis, synthesis, and evaluation." The four hypotheses of this study were set up in terms of each of the three objectives as well as their total. It was expected that the treatment group would achieve a higher mean score than the non-treatment

group on items assigned to each of the three objectives and their total.

A t-test used to analyze the pretest data showed no significant difference between the two groups with students' mathematics scores in the 1968-69 academic year.

A t-test analysis on the posttest data revealed that the four alternative hypotheses of this study were rejected.

Several limitations may have accounted for these results:

(a) The students selected in the treatment sample were not involved in all of the areas in the industrial arts labs.

(b) All of the students in the treatment group except one had taken industrial arts less than seven months before they took the 1970 mathematics departmental examination.

(c) Teachers in the above-mentioned four schools may have lacked experience in teaching girls industrial arts since this would be the teachers' first attempt at such a course.

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Chapter 1

The Problem

I. Introduction

This study investigated whether present grade nine female students in Edmonton Separate School System who had taken at least one academic year of industrial arts during their junior high school education achieved significantly higher scores on the 1970 Department of Education mathematics examination than students who had never taken this course.

II. Purpose

The purpose of this study was to examine part of the first objective of the industrial arts program recommended by Ziel, LeBlanc and Manuel (1966, p. 8) and conducted in the Department of Industrial and Vocational Education, The University of Alberta. The objective was "To provide an environment where students can reinforce and apply the academic disciplines." This study attempted to find the effect of taking industrial arts on a learner's achievement in grade nine mathematics in Edmonton during the academic year 1969-70.

The term "achievement" was defined in terms of Bloom's Cognitive Domain. According to Bloom (1956, pp. 201-7), the Cognitive Domain included knowledge, comprehension, application, analysis, synthesis and evaluation.

III. Rationale

The rationale of this study was based upon three major premises. They were as follows: (1) the objectives of an educational program were very important for program guidance and direction; (2) it had been considered suitable and desirable for girls to take industrial arts; and (3) industrial arts, as with other subjects in school, encompassed the study of the application of mathematics. These three premises were delineated respectively as follows:

1. The above-mentioned specific objective of the industrial arts program needed to be examined because the objectives of educational programs had long been considered very important for program guidance and direction. As Wilber and Pendered (1967, p. 67) pointed out, "objectives are vital to an educational program. They provide direction, guidance, and enable evaluation to take place." Wall (1965, p. 47) held similar viewpoints to Wilber's and Pendered's. Wall stated, "It is a truism to state that a program should be based on its objectives and few would argue the validity of the idea."

2. Stark (1967, p. 74) stated, ". . . to illustrate an idea that has been steadily gaining acceptance in modern educational practice in the two decades of the 50's and 60's--that of girls taking industrial arts." Fink (1965, p. 56) held similar viewpoints to Stark's. Fink emphasized, "More important however, we proved that industrial arts knows no barriers of sex. Indeed, it is an

important subject and one that should be made available to all students, girls or boys, in either the academic, general or commercial track."

3. Industrial arts, as with other subjects in school, encompassed the study of applications of mathematical concepts, principles, theories, and/or techniques. As Wall (1965, p. 47) stated, "Industrial arts has been visualized as the study of applications of mathematics and science." He also made the following statements:

For many years industrial arts has made use of mathematics in its content. The claim that industrial arts students must make use of principles of mathematics had long been made.

Industrial arts curriculum builders have followed three general approaches in drawing content from mathematics.

1. Special emphasis on projects calling for applications of mathematics.

2. Illustration and testing of mathematical principles.

3. Bodily adoption of certain parts of mathematics.

Feirer (1965, p. 15) held similar viewpoints to Wall's. Feirer stated,

. . . We should make use of applied science and mathematics in our industrial arts whenever it is feasible. As a matter of fact, mathematics in particular makes extensive use of industrial arts. Anyone who has reviewed a junior high school math text knows that a large portion of the problems in the text are drawn directly from industry and technology.

Appendix A shows in some detail examples of application of mathematical concepts, principles, theories, and/or techniques to the six areas of industrial arts. The examples are based upon activities suggested for students by the curriculum guide of the Alberta Department of Education, and

supported by specific examples from California State Department of Education.

The above-discussed three premises formed the basis for undertaking this study.

IV. Hypotheses

According to Woodward (1962, p. 41), "Industrial arts experiences have reinforced, applied, and extended mathematics, through activities requiring mathematical solutions." Feirer and Lindbeck held similar viewpoints to Woodward's. Feirer and Lindbeck (1964, pp. 29-30) stated, "Industrial arts utilizes and reinforces many mathematics concepts in its extensive use of measuring devices and computational formulas."

The above two authoritative statements would lend support to the appropriateness of the following four hypotheses.

These four alternative hypotheses were set up in terms of the blueprint of 1970 grade nine mathematics departmental examination (See Table 1).

1. The treatment group, composed of grade nine female students who took industrial arts for at least one academic year, would have a higher mean score than the non-treatment group (grade nine female students who have never enrolled in industrial arts) on items assigned to the "knowledge" objective. "Knowledge" was the first level of the objectives of the 1970 grade nine mathematics departmental examination.

Table 1

Blueprint of 1970 Grade Nine Mathematics
Departmental Examination

OBJECTIVES	Topic or Content Area					EMPHASIS (%)
	Algebraic Expressions	Formulas and Variation	Equivalent Conditions	Mathematical Systems	Geometry	
1. KNOWLEDGE	61, 81, 88	5		8, 33, 34, 49, 50, 79	2, 35, 54, 55, 67, 71, 76, 84, 86, 94	20
2. COMPRE- HENSION	1, 3, 4, 14, 15, 16, 18, 21, 32, 36, 39, 40, 41, 57, 59, 62, 63, 66, 69, 74, 77, 78, 85, 87, 95	11, 22, 27, 37, 58, 10, 20	47, 52, 90, 23, 25, 30, 31, 44, 99, 100	28, 70, 89	13, 42, 60	48
3, 4, 5 and 6 HIGHER MENTAL PROCESSES APPLICATION ANALYSIS SYNTHESIS EVALUATION	53, 56, 6, 7, 19, 38, 65, 72, 73, 75, 80, 82, 83, 91, 12	9, 17, 26, 43, 45, 46, 51, 64, 97	92, 98	24, 29, 68	48, 93, 96	32
Emphasis %	43	17	12	12	16	100

2. The treatment group would have a higher mean score than the non-treatment group on items assigned to the "comprehension" objective. "Comprehension" was the second level of the objectives of the 1970 grade nine mathematics departmental examination.

3. The treatment group would have a higher mean score than the non-treatment group on items assigned to the "application, analysis, synthesis, and evaluation" objective. "Application, analysis, synthesis, and evaluation" was the third level of the objectives of the 1970 grade nine mathematics departmental examination.

4. The treatment group would have a higher mean score than the non-treatment group on the grade nine mathematics departmental examination.

V. Significance of Study

The significance of this study is illustrated by the following two statements:

1. It may be considered suitable and important for girls to take industrial arts since industrial arts, as with other subjects in school, encompasses the study of the application of mathematics.

2. It may assist the principals of separate junior high schools in Edmonton to decide whether they should allow and encourage female students to take industrial arts if support is found for any of the four hypotheses.

VI. Definition of Terms

1. Industrial Arts. According to Feirer and Lindbeck (1964, p. 29), industrial arts for junior high school boys and girls has as its primary function the provision of industrial experiences of an exploratory or orientational nature....Such courses offer a wide range of activities to enable youth to develop a clearer understanding of industrial materials and processes and to explore individual aptitudes and aspirations. Its mission then is two-fold: it introduces students to the world of industry and technology, and it guides them in terms of vocational interests and abilities.

Industrial arts, as suggested by the Department of Education (1969, p. 6), should include the following teaching units: electricity, plastics, earths, visual communication, woods, metals, electronics-computer, power, and graphic communication. However, according to the grade nine industrial arts teachers in the four schools used in this investigation, the grade nine female students have primarily been offered the areas of ceramics, graphic arts, plastics and woodwork only.

2. Treatment Group. This group consisted of the grade nine female students in the four schools stated above who took industrial arts in the 1969-70 academic year and/or who had taken this course at any time during their junior high school education. There were thirty-four grade nine female students in this group.

3. Non-treatment group. This group consisted of the remaining grade nine female students who attended the same schools and the same classes in both their grade eight and/or grade nine school year as those selected in the treatment group sample. These students had never taken industrial arts in junior high school. There were seventy-eight grade nine female students in this group.

4. Knowledge. According to Bloom (1956, p. 201), "knowledge . . . involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting. For measurement purposes, the recall situation involves little more than bringing to mind the appropriate material. Although some alternation of the material may be required, this is a relatively minor part of the task. The knowledge objectives emphasize most of the psychological processes of remembering. The process of relating is also involved in that a knowledge test situation requires the organization and reorganization of a problem such that it will furnish the appropriate signals and cues for the information and knowledge the individual possesses."

5. Comprehension. According to Bloom (1956, p. 204), comprehension "represents the lowest level of understanding. It refers to a type of understanding of apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other

material or seeing its fullest implications."

6. Application. According to Bloom (1956, p. 205), application is seen as "the use of abstractions in particular and concrete situations. The abstractions may be in the form of general ideas, rules of procedures, or generalized methods. The abstractions may also be technical principles, ideas, and theories which must be remembered and applied."

7. Analysis. According to Bloom (1956, p. 205), analysis is defined as "the breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit. Such analyses are intended to clarify the communication, to indicate how the communication is organized, and the way in which it manages to convey its effects, as well as its basis and arrangement."

8. Synthesis. According to Bloom (1956, p. 206), synthesis is explained as "the putting together of elements and parts so as to form a whole. This involves the process of working with pieces, parts, elements, etc., and arranging and combining them in such a way as to constitute a pattern or structure not clearly there before."

9. Evaluation. According to Bloom (1956, p. 207), evaluation is concerned with "judgments about the value of material and methods for given purposes. Quantitative and qualitative judgments about the extent to which material

and methods satisfy criteria. Use of a standard of appraisal. The criteria may be those determined by the student or those which are given to him."

VII. Delimitations

There were two major delimitations to this study. They were as follows:

1. All the grade nine male students in Edmonton took industrial arts at least one year in either grade eight or grade nine during their junior high school education. In other words, there were no grade nine male students that could have been used as the non-treatment group for this study. Accordingly, the investigator was forced to employ grade nine female students in the treatment group and the non-treatment group of this study.

2. To eliminate any cross effect due to school system, it was decided that either the public or separate system must be used. Random selection resulted in the choice of the Edmonton Separate School System. Of thirty separate junior high schools in Edmonton there were only the four schools: St. Edmund; St. Gabriel, St. Thomas More, and Holy Cross which had female students taking industrial arts. Thus, all the students selected for the treatment group and the non-treatment group for this study were from these four schools.

VIII. Limitations

The two main limitations to this study were as follows:

1. According to industrial arts teachers in the four schools, the grade nine female students had not participated equally in all the areas in their industrial arts labs. Generally speaking, the grade nine female students were more interested in ceramics, graphic arts, plastics and woodwork than in electricity and metalwork. This may have been a limiting factor on the application of mathematical concepts, principles, theories, and/or techniques to industrial arts and vice versa.

The areas of industrial arts offered for grade nine female students in the four schools were as follows:

- (a) St. Edmund: ceramics, visual communication, graphic communication, plastics and electricity.

- (b) St. Gabriel: leather, crafts, plastics, ceramics, lapidary, bench metal, sheet metal, woodwork, graphic arts, graphic communication, electricity, electronics and power mechanics.

- (c) St. Thomas More: woodwork, plastics, ceramics, visual communication (drafting and photography).

- (d) Holy Cross: ceramics, woodwork, plastics, graphic arts (off-set printing and photography) and drafting (isometric and oblique drawings).

2. The final grades achieved in courses the previous year (1968-69) by the students in both the treatment

group and the non-treatment group were used to determine whether or not there was a significant difference in mathematics achievement between the two groups. This study may have been limited by the validity of these grades.

XI. Assumptions

There were three major assumptions in this study. They were as follows:

1. The 1970 grade nine mathematics departmental examination was a valid indicator of achievement in mathematics.
2. The curriculum of instruction for the treatment group was similar to that curriculum recommended by the Department of Education in Edmonton in September 1969.
3. The grade nine female students' achievement in mathematics was not significantly influenced by their taking any other elective courses in grade nine such as religious education, music (instrumental or choral), art, dramatics, home economics, typewriting or oral French.

Chapter 2

Review of Literature.

I. Sources

There were three major sources of literature reviewed by this study. They were as follows:

1. Education Index and Subject Catalogue under the title of Industrial Arts and Mathematics

The investigator reviewed the Education Index under the heading of Industrial Arts Education and Mathematics from Volume 12 (July 1959-June 1960) to Volume 19 (July 1968-June 1969) and most recent ones namely Volume 41, Number 1 (September 1969), Volume 41, Number 4 (December 1969), Volume 41, Number 5 (January 1970) and Volume 41, Number 6 (February 1970), and found some papers issued which were related to this study.

In addition, the Subject Catalogue under the title of Industrial Arts and Mathematics was reviewed and some materials were found relating to this study.

In reviewing the above-stated two sources, the investigator obtained some documents which were related to this study.

2. Dissertation Abstracts

The investigator reviewed Dissertation Abstracts under the heading of Industrial Arts Education from volume 20 (July 1959-June 1960) to Volume 29 (July 1968-June 1969) and found a few doctoral dissertations which

were related to this study.

3. Master's Theses in Education

The investigator reviewed Master's Theses in Education edited by H. M. Silvey under the heading of Industrial Arts Education from Number 9 (1959-60) to Number 18 (1968-69) and found a number of master's theses which were related to this study. All of the master's theses related to this study were reviewed through interlibrary loan requests.

II. Categories

The three categories of related literature were delineated as follows:

1. Related Documents

The trend toward junior high school female students taking industrial arts was found to be not new. They were succeeding in these courses. As Baer (1964, p. 87) pointed out,

Another trend, which is not new, is that more girls are enrolling in industrial arts courses in drafting, electronics, and graphic arts as an elective in the 9th grade. Girls are succeeding in these courses with little modification of content.

Many principals were convinced that the industrial arts program in junior high school had value to all of the students enrolled in the school. As Patterson (1965, p. 32) stated,

The demands for technological literacy in coming generations of Americans indicate that girls can benefit greatly from selected courses in industrial arts.

Girls have been encouraged to take industrial arts.

As Ratti (1969, p. 64) said,

The survey shows that girls taking part in industrial-arts courses are encouraged, in some cases, to really "get involved" by their teachers- although most girls are now only in drafting courses.

The following was summarized from Stark's (1967, pp. 74-76) statements.

(a) There has been an increase in the number of industrial arts programs of both a compulsory and an elective nature for girls in secondary schools in the United States since 1954.

(b) The girls were enrolled in all areas of industrial arts. The largest number of girls was enrolled in crafts and the next highest enrolment in drafting. The smallest number of girls was enrolled in power mechanics and photography.

(c) The response to programs of industrial arts for girls has been over-whelming. In most cases the number of girls signing for the courses, when offered, greatly exceeded the number that could be accepted.

The following statements indicated the relationship of mathematics to industrial arts and the reinforcement in mathematics when students took industrial arts.

The coordination of mathematics in the industrial arts problem and the mathematics class problem is not a one way street. It involves mutual understanding of the problems and cooperation in solving them. (Carpenter, 1961, p. 35).

The application of mathematics is an integral part of the industrial arts experiences in grades seven through twelve. The extent to which mathematics is used in a particular industrial arts course is dependent upon the grade level and ability of the students. The introduction of these mathematics experiences in mathematics courses is dependent upon these same factors. (California State Department of Education, 1960, p. 5).

Industrial arts courses offered in California public schools are rich in opportunity for students to make practical use of mathematics. In taking advantage of this opportunity, students deepen the understanding, improve the skill, and extend the appreciation of mathematics they acquire in regular mathematics courses. They also acquire insights that intensify their interest in mathematics. (California State Department of Education, 1960, p. iii).

Industrial arts utilizes and reinforces many mathematics concepts in its extensive use of measuring devices and computational formulas (Feirer and Lindbeck, 1964, pp. 29-30).

Industrial arts experiences have reinforced, applied, and extended mathematics, through activities requiring mathematical solutions.

. . . Relationship of industrial arts to mathematics: Students make extensive use of measuring processes. Accuracy and computational skills are developed. A wide range of experiences is provided in the use of symbols and

formulas. Computations are an integral part of many processes and jobs. Concepts of tolerance are developed. Skills are acquired in the estimating and judging of size, quantity, and fit. (Woodward, 1962, pp. 41-42).

In addition, Woods (1964, p. 19) stated the relationship between mathematics and industrial arts is as follows:

. . . let's make four points about the relation of mathematics to industrial arts: (1) mathematics is a system of quantitative thinking; (2) students learn quantitative thinking through problem-solving activity; (3) in teaching industrial arts, problem-solving situations occur naturally and quantitative thinking can be taught effectively; and (4) the integration of mathematics and industrial arts is a natural thing.

2. Related Doctoral Dissertations

Two doctoral dissertations were related to this study:

(a) Bowman (1959, pp. 3226-3227) in a study of the basic mathematical skills needed to teach industrial arts in the public schools stated,

On the basis of the evidence in this study, the college industrial arts teacher-preparation student should be required to complete courses in elementary algebra, plane geometry, intermediate algebra, solid geometry, and trigonometry.

(b) Noll (1967, pp. 1008-A--1009-A) in a study of mathematics and science requirements for drafting technicians stated,

Findings reflected that the application of mathematics skills to problems encountered by drafting technicians was approximately twice as frequent as the application of science skills.

3. Related Master's Theses

Four master's theses were related to this study:

(a) La Plant (1959, pp. 64-65) in a study of an investigation of some possibilities for increasing mathematical understanding through industrial arts said,

The correlation of mathematics and industrial arts will probably increase the student's proficiency in industrial arts activities as well as contribute materially to his understanding of basic mathematical concepts.

Through a variety of examples, it has been shown that in almost all areas of industrial arts there are opportunities for improving mathematics understanding. While certain industrial arts activities such as woodworking, graphic arts, handicrafts, and basic metalworking lend themselves to the development of the more elementary mathematical concepts and operations, opportunities for more advanced topics do exist.

(b) Fox (1961, p. 53) in a study of the application of science and mathematics in industrial arts said,

Applications of mathematics in industrial arts may be taught at any grade level from elementary through high school.

(c) Rolf (1965, p. 38) in a study to determine the relationship of grades earned in industrial arts to the grades earned in certain other subjects in senior high school said,

There was a significant correlation between the grades in industrial arts and mathematics as the courses were conducted at Shawnee Mission West High School.

(d) McAdams (1963, pp. 107-108) in a study of the application of mathematical concepts in industrial drawing in the junior high school said,

An analysis and comparison of the areas of

overlap was made and a list of mathematical concepts which showed definite possibility for application in industrial drawing was established.

Recommendations designed to encourage instructional improvement in mathematics by drafting teachers were listed.

III. Summary

The review of literature revealed two major points with reference to girls, industrial arts, and mathematics. They were:

1. An industrial arts program in junior high school had value for female students. Thus, girls have been encouraged to take these courses. The number of secondary schools in which industrial arts was either compulsory or elective for girls and the number of girls enrolled in this course have greatly increased during the period of this review.

2. In industrial arts activities, there were numerous and varied situations in which the students may have acquired additional mathematical knowledge as well as reinforced those concepts, principles, theories, and/or techniques with which they may have already been familiar.

Chapter 3

Procedures

I. Introduction

All the students selected for the treatment group and the non-treatment group for this study were from the four schools as stated in the delimitations. A posttest design was used in this study since a pretest measure was impossible to obtain. Students' mathematics scores of last year namely 1968-69, collected from the four schools, were used as pretest data. Students' mathematics scores on the 1970 departmental examination were employed as posttest data. The population and sample selection, research design, instrumentation, administration of instrumentation, and data collection for this study were described in more detail as follows:

II. Population and Sample Selection

All the samples that have been selected for the treatment group and the non-treatment group were from the four schools stated above. In St. Gabriel, St. Thomas More, and Holy Cross, all the grade nine female students who took industrial arts in the 1969-70 academic year and/or who had taken this course at any time during their junior high school education were selected as samples for the treatment

group. The non-treatment group consisted of the remaining grade nine female students who attended the same schools and the same classes in the 1968-69 and/or the 1969-70 academic year as those selected as samples for the treatment group.

In St. Edmund all the grade nine female students in the 9A class were taking industrial arts and those in the 9B class were taking either art or drama instead of industrial arts. According to the principal of this school, this was done for teaching convenience only. The teachers of social studies, language and French for the two classes were different but the teacher of mathematics for the two classes was the same. Since the mathematics taught to both classes was the same it seemed acceptable to use these classes in the sampling. This assumption was borne out in the results of the pretest which indicated that the St. Edmund's group was similar to the other schools on the variable measured.

The distribution of the students used in the sampling is shown as follows:

Table 2
Distribution of the Students in the
Two Groups of This Study

Name of School	Number of Students Selected for the Treatment Group	Number of Students Selected for the Non-treatment Group
St. Edmund	13	13
St. Gabriel	4	18
St. Thomas More	7	26
Holy Cross	10	21
Total	34	78

There was only one grade nine female student in St. Gabriel who took industrial arts in the 1968-69 academic year and who also took the course in the 1969-70 academic year. All the other students in the treatment group took industrial arts in the 1969-70 year only. Because all the grade nine female students in the four schools met the definition of the treatment group or the non-treatment group as determined by the investigator, randomization was unnecessary.

III. Research Design

The design of this study was posttest only. The form of the posttest was as follows: (Campbell and Stanley, 1963, p. 195):

$$\begin{array}{cc} R_1 & \times & O_1 \\ R_2 & & O_2 \end{array}$$

R_1 stood for the samples selected as treatment

group. There were thirty-four students in this group.

X stood for the grade nine female students in the four schools who took industrial arts in the 1969-70 academic year and/or who had taken this course during their junior high school education.

O_1 stood for the departmental mathematics scores of those students selected as treatment group.

R_2 stood for the samples selected as non-treatment group. There were seventy-eight students in this group.

O_2 stood for the departmental mathematics scores of those students selected as non-treatment group.

Thus, the design of this study was used to compare whether the grade nine female students, who took industrial arts in the 1969-70 academic year and/or had taken this course during their junior high school education, achieved higher scores in each of the three objectives (and their total) set up by the 1970 grade nine mathematics departmental examination than those who had never taken this course in their junior high school education.

IV. Instrumentation

The instrumentation of this study was the 1970 grade nine mathematics departmental examination administered by the Department of Education in Edmonton.

The objectives of this examination were set up in terms of Bloom's Cognitive Domain and were classified in three levels: (a) knowledge, (b) comprehension, and (c)

application, analysis, synthesis, and evaluation.

This examination was a semi-standardized achievement type of test. According to the information sent by the Examination Branch, Department of Education in Edmonton, to the principals of all Alberta junior high schools, the nature of the semi-standardized achievement test was as follows:

Commencing with the 1969-70 school term the usual grade IX June departmental examination was discontinued and a battery of junior high school achievement tests were administered in March 1970.

Each test, including grade nine mathematics, was based on the student's entire achievement in junior high school (Grades 7,8, and 9). In the 1970 tests there was a somewhat greater emphasis placed on the Grade IX level content than the Grade VII or Grade VIII level content.

V. Administration of Instrumentation

The blueprint of the 1970 grade nine mathematics departmental examination was obtained from the Examination Development Officer, Examination Branch, Department of Education in Edmonton.

Information regarding the nature of this examination was obtained from the Supervisor of Examinations, Examination Branch, Department of Education in Edmonton.

VI. Data Collection

The 1968-69 mathematics scores of all the students in the treatment group and the non-treatment group were collected and used as the pretest data for this study. The above students' answer sheets on the 1970 grade nine mathematics departmental examination administered in March 1970 were collected and used as the posttest data for this study.

Approval to collect data was secured from W. A. Kiffiak, Administrative Assistant of the Division of Field Experiences, Faculty of Education, The University of Alberta, and J. L. Picard, Administrative Assistant of the Department of Instruction, Separate School Board in Edmonton. After making an appointment with each principal in each of the four schools involved, the investigator went to the four schools and collected the pretest data from students' cumulative record cards.

The posttest data and the key for the departmental examination were obtained through the permission of E. J. Church, Director of Special Services, Department of Education in Edmonton and the permission of Y. Iriye, Chief-clerk of Examination Branch, Department of Education in Edmonton.

Chapter 4

Analysis of Data

I. Method of Analysis

The following statistical methods were used to analyze the data collected.

1. The t-test for testing Significance of the Difference between Two Means for Independent Samples (Ferguson, 1959, pp. 167-69), was used to determine whether there was significant difference between the two groups in each of the four schools, separately, with students' mathematics scores of the 1968-69 school term. The reason for using a t-test here was that there were only two samples--the students who took industrial arts in the academic year of 1968-69 and/or 1969-70 and those who have never taken this course during their junior high school education. As Campbell and Stanley (1963, p. 196) stated "The simplest form of the statistics for the design of posttest only would be the t-test. The design of posttest only is perhaps the only setting for which this test is optimal." One reason for comparing the two groups in each of the four schools, separately, with students' mathematics scores of last year was that the mathematics teacher in each school may have had a different standard of marking from that of the other school. Another reason was that the number of subjects in

the treatment group and the non-treatment group in each school was not the same except for St. Edmund school.

The computer program ANOV 10 was set up by the Division of Educational Research Services at this University for the t-test as stated above. The investigator followed this program to obtain the results needed which were computed by the IBM 360/67 computer.

2. When no significant difference between the two groups in mathematics scores in any of the four schools as previously mentioned occurred, the t-test (computer program ANOV 10) was again used to compare the total numbers of the two groups (thirty-four students in the treatment group and seventy-eight students in the non-treatment group) in mathematics scores. Since if significance is approached in any of the two groups for the four schools, the possibility of obtaining significant difference between total groups is higher.

3. When there was no significant difference between two total numbers of the two groups in mathematics scores, then, computer program test 06 was used to develop students' departmental mathematics scores from students' data cards punched by the machine IBM 1230/534 from students' answer sheets. Also, four key cards were punched by the IBM 1230/534 from four answer sheet keys which were made in terms of the blueprint (p. 5), for each of the three objectives set up by the 1970 grade nine mathematics departmental examination and for their total. These were

processed by the IBM 1230/534 in the same way as the students' answer sheets. The scores for each student on each of the three objectives and their total are computed, printed, and punched on to new cards. Then, the new cards were used for the t-test (computer program ANOV 10) to obtain the information needed for analyzing the four hypotheses set up by this study.

4. When there was significant differences between the two groups in mathematics scores in the 1968-69 academic year in certain schools, the sample selected from that school was not used for this study. If there was significant differences between the total numbers of the two groups in mathematics scores in the 1968-69 academic year, the samples selected from certain schools which show nearly significant differences between the two groups in mathematics scores were not used for this study.

The .05 level of significance for a two-tailed test was used to decide whether there was significant differences between two comparing groups in any case of this study. The .05 level of significant was adopted due to convention. The two-tailed test rather than one-tailed test was used since the treatment group may have achieved either a higher or lower mean score than the non-treatment group on the grade nine mathematics departmental examination. According to Ferguson (1959, p. 165),

An investigator may wish to test the null hypothesis, $H_0: \mu_1 - \mu_2 = 0$, against the alternative, $H_1: \mu_1 - \mu_2 \neq 0$. If H_0 is rejected, the decision

is that a difference exists between the two means. No assertion is made about the direction of the difference. Such a test is a nondirectional test. A test of this kind is sometimes called a two-tailed or two-sided test, because if the normal distribution, or the distribution of t , is used, the two tails, or the two sides, of the distribution are employed in the estimation of probabilities.

II. Analysis of Pretest Data

1. Comparison between the two groups in this study in each of the four schools, separately, with students' mathematics scores in the 1968-69 academic year was as follows:

T-test Significance of the Difference between Two Means for Independent Samples (computer program ANOV 10) was handled in the following manner for each of the four schools.

(1) Although the four hypotheses set up in this study were in the alternative form, the null form of the hypotheses was made here for statistical testing. The statistical statement of the hypothesis was:

$$H_0: \mu_1 - \mu_2 = 0; H_1: \mu_1 - \mu_2 \neq 0$$

where H_0 = null hypothesis,

H_1 = alternative hypothesis,

μ_1 = population mean of the treatment group in each of the four schools, and

μ_2 = population mean of the non-treatment group in each of the four schools.

- (2) The level of significance was set a priori at .05.
- (3) Computation was carried out on the IBM 360/67 computer at the computing Center, General Service Building, The University of Alberta, using programs from the Division of Educational Research Services at this University. Computation was based upon the method described by Ferguson (1959, pp. 167-169). A summary of the t-test (computer program ANOV 10) for the two groups in this study in each of the schools followed.

(a) St. Edmund

The decision rule for the samples selected for this study from St. Edmund was: if $t \geq 2.064$, then the null hypothesis was rejected.

The results obtained from the t-test analysis of the data from St. Edmund are summarized in Table 3. According to the decision criteria established, the H_0 was not rejected. The observation was made that there was no significant difference in performance between the treatment and the non-treatment groups with students' mathematics scores of 1968-69.

Table 3
Analysis of Pretest Data
in St. Edmund

Name of Group	N	Mean	S.D.	D.F	t	P-Two Tail
Treatment	13	61.54	8.41			
				24	-0.638	0.530
Non-treatment	13	65.77	21.38			

(b) St. Gabriel

The decision rule for the samples selected for this study from St. Gabriel was: if $t = 2.086$, then the null hypothesis was rejected.

The results obtained from the t-test analysis of the data from St. Gabriel are summarized in Table 4. According to the decision criteria established, the H_0 was not rejected. It was found that there was no significant difference in performance between the treatment and non-treatment groups with students' mathematics scores of the 1968-69 academic year.

Table 4
Analysis of Pretest Data
in St. Gabriel

Name of Group	N	Mean	S.D.	D.F.	t	P-Two Tail
Treatment	4	66.25	14.74			
				20	-0.508	0.617
Non-treatment	18	70.17	12.95			

(c) St. Thomas More

The decision rule for the samples selected for this study from St. Thomas More was: if $t \geq 2.039$, then the null hypothesis was rejected.

The results obtained from the t-test analysis of the data from St. Thomas More are summarized in Table 5. According to the decision criteria established, the H_0 was not rejected. There was no significant difference in performance between the treatment and non-treatment groups with students' mathematics scores of 1968-69.

Table 5
Analysis of Pretest Data
in St. Thomas More

Name of Group	N	Mean	S.D.	D.F.	t	P-Two Tail
Treatment	7	53.57	13.55			
				31	-0.801	0.429
Non-treatment	26	58.46	13.99			

(d) Holy Cross

The decision rule for the samples selected for this study from Holy Cross was: if $t \geq 2.045$, then the null hypothesis was rejected.

The results obtained from the t-test analysis of the data from Holy Cross are summarized in Table 6. According to the decision criteria established, the H_0 was not rejected. Again, there was no significant difference in performance between the treatment and non-treatment groups with students' mathematics scores of last year namely 1968-69.

Table 6

Analysis of Pretest Data
in Holy Cross

Name of Group	N	Mean	S.D.	D.F.	t	P-Two Tail
Treatment	10	60.50	15.72			
				29	0.290	0.774
Non-treatment	21	58.57	17.19			

Summarizing these results, there was no significant difference between the treatment and non-treatment groups in any of the four schools with students' mathematics scores in the 1968-69 academic year.

2. Comparison between the total numbers of the two groups in this study with students' mathematics scores in the 1968-69 academic year was as follows:

T-test Significance of the Difference between Two Means for Independent Samples (computer program ANOV 10) was again used. The t-test was handled in the following manner.

- (1) The statistical statement of the hypothesis was:

$$H_0: \mu_1 - \mu_2 = 0; H_1: \mu_1 - \mu_2 \neq 0$$

where H_0 = null hypothesis,

H_1 = alternative hypothesis,

μ_1 = population mean of the treatment group in this study, and

μ_2 = population mean of the non-treatment group in this study.

- (2) The level of significance was set a priori at .05.
- (3) The decision rule was: if $t \geq 1.98$, then the null hypothesis was rejected.
- (4) Computation was identical to the Analysis of Pretest Data, item 1.

The results obtained from the t-test analysis of the data from the four schools are summarized in Table 7. According to the decision criteria established, the H_0 was not rejected. There was no significant difference in performance between the total numbers of the treatment and non-treatment groups with students' mathematics scores of 1968-69.

Table 7

Analysis of Pretest Data in the Four Schools
 St. Edmund, St. Gabriel, St.
 Thomas More, and Holy Cross

Name of Group	N	Mean	S.D.	D.F.	t	P-Two Tail
Treatment	34	60.15	13.31			
				110	-0.687	0.493
Non-treatment	78	62.41	16.87			

III. Analysis of Posttest Data

The analysis of posttest data is to test the four hypotheses set up by this study.

The computer program Test 06 (1230 Test Scoring) was first used to obtain key scores for each of the three objectives set up by the 1970 grade nine mathematics departmental examination and for their total, individual test scores gained for each of the three objectives and their total, and new cards punched with the individual test scores which were in turn used for using t-test (computer program ANOV 10) to acquire the output needed for analyzing the four hypotheses of this study. The manner handled was identical to that previously referred to under the heading of Analysis of Pretest Data, item 2.

1. Hypothesis #1

From the output of using the t-test (computer program ANOV 10), the data for testing hypothesis # 1 is

summarized in Table 8. According to the decision criteria established, the H_0 was not rejected. It appears that the treatment group did not have a higher mean score than the non-treatment group on items assigned to the "knowledge" objective. "Knowledge" was defined as the first level of the objectives of the 1970 grade nine mathematics departmental examination.

Table 8
Data for Testing Hypothesis #1

Name of Group	N	Mean	S.D.	D.F.	t	P-Two Tail
Treatment	34	7.32	2.85			
				110	0.923	0.358
Non-treatment	78	7.94	3.34			

2. Hypothesis #2

Using the t-test (computer program ANOV 10), the data for testing hypothesis #2 has been summarized in Table 9. According to the decision criteria established, the H_0 was not rejected. The treatment group did not have a higher mean score than the non-treatment group on items assigned to the "comprehension" objective. "Comprehension" was defined as the second level of the objectives of the 1970 grade nine mathematics departmental examination.

Table 9

Data for Testing Hypothesis #2

Name of Group	N	Mean	S.D.	D.F.	t	P-Two Tail
Treatment	34	17.38	5.74			
				110	0.813	0.418
Non-treatment	78	18.59	7.70			

3. Hypothesis #3

Using the t-test (computer program ANOV 10), the data for testing hypothesis #3 has been summarized in Table 10. According to the decision criteria established, the H_0 was not rejected. The treatment group did not have a higher mean score than the non-treatment group on items assigned to the "application, analysis, synthesis, and evaluation" objective. "Application, analysis, synthesis, and evaluation" as defined by this study was the third level of the objectives of the 1970 grade nine mathematics departmental examination.

Table 10

Data for Testing Hypothesis #3

Name of Group	N	Mean	S.D.	D.F.	t	P-Two Tail
Treatment	34	12.32	4.29			
				110	1.179	0.241
Non-treatment	78	13.59	5.52			

4. Hypothesis #4

Using the t-test (computer program ANOV 10), the data for testing hypothesis #4 has been summarized in Table 11. According to the decision criteria established, the H_0 again was not rejected. Results showed that the treatment group did not have a higher mean score than the non-treatment group on the grade nine mathematics departmental examination.

Table 11
Data for Testing Hypothesis #4

Name of Group	N	Mean	S.D.	D.F.	t	P-Two Tail
Treatment	34	37.03	11.08	110	1.055	0.294
Non-treatment	78	40.12	15.25			

In summary, the four hypotheses set up by this study were rejected. The treatment group did not achieve a significantly higher mean score than the non-treatment group on items assigned to each of the three objectives and their total set up by the 1970 grade nine mathematics departmental examination.

Chapter 5

Conclusions, Summary, and Recommendations

I. Conclusions

The results of this study and the possible reasons for these results are presented briefly. The results of this study were presented in relationship to the four stated hypotheses. A summary of the results was tabulated and presented in Table 12.

Table 12
Summary of Results

Hypotheses	Null Hypotheses (Values of P)	
	Rejected	Not Rejected
#1		0.358
#2		0.418
#3		0.241
#4		0.294

The following results indicated in the above Table were revealed by this study.

There was no significant difference in performance on each of the three levels of the objectives of the 1970

grade nine mathematics departmental examination and their total between the treatment group and the non-treatment group.

The reasons for the above-stated results seemed to have resulted from the following statements related to major limitations of this study.

(a) The students in the sample for the treatment group in this study have not been involved in all of the areas in the industrial arts labs. Generally speaking, these students were more interested in ceramics, graphic arts, plastics and woodwork than in electricity and metalwork. This may have limited the effect of taking industrial arts on mathematics achievement.

(b) All of the students in the sample for the treatment group in this study except one began to take industrial arts during their junior high school education in September 1969 and took the mathematics departmental examination in March 1970. This means that they had taken industrial arts for less than seven months before they took the examination. This may have limited the effect of taking industrial arts on mathematics achievement.

(c) Industrial arts teachers in the four schools may have lacked experience in teaching girls industrial arts since this would be the teachers' first attempt at such a course. This lack of experience may have limited the students' learning in industrial arts and, in turn, limited the effect of learning this course on

mathematics achievement.

II. Summary

The general problem of this study was to examine part of an objective of the industrial arts program recommended by the Department of Industrial and Vocational Education, The University of Alberta, in 1966. The objective was "To provide an environment where students can reinforce and apply the academic disciplines." Delineation of this general problem led to an attempt to find the effect of taking industrial arts on a learner's achievement in grade nine mathematics in Edmonton during the academic year 1969-70. The four hypotheses (pp. 4-6) were thus set up to be tested by this study.

A treatment group and a non-treatment group were established for this study. The treatment group consisted of thirty-four grade nine female students in St. Edmund, St. Gabriel, St. Thomas More, and Holy Cross who took industrial arts in the 1969-70 academic year and/or who had taken this course at any time during their junior high school education. The non-treatment group consisted of the seventy-eight remaining grade nine female students who were attending the same schools and the same classes in their grade eight and/or grade nine school year as those selected as samples for the treatment group. These students had never taken industrial arts in junior high school.

A Computer program Test 06 and a t-test (computer

program ANOV 10) were used to examine that posttest data relevant to the four stated hypotheses.

The results showed that an attempt to differentiate between achievement of the respective groups of students of the 1970 mathematics departmental examination revealed no significant differences on each of the three objectives and their total set up by this examination. Accordingly, the four hypotheses of this study were rejected.

III. Recommendations

The grade nine mathematics departmental examination was one of the most valid measurement devices available. It is recommended for further study that an attempt be made to analyze the items of the mathematics examination in order to examine which items would be easier for a treatment group than for a non-treatment group, and to ascertain which level of the objectives set up by the examination these items belonged.

In order to carry out this further study, the following five suggestions should be incorporated.

(a) Male, rather than female students, should be sampled for the treatment and non-treatment groups. This method would ensure that students in the treatment group would have been involved in all areas of the industrial arts labs, and that industrial arts teachers would have had experience in teaching males this course.

(b) The prospective researcher should give the

students' drawn in the samples of this study, a standardized pretest. The students' responses from this standardized test would be used as pretest data rather than their final course grades. A more valid indicator of the criteria would be assured through this alternative method.

(c) Students in the treatment group should have taken industrial arts for at least one complete academic year before taking the departmental examination. This will allow the students enough time to reinforce mathematical concepts, principles, theories, and/or techniques when they are exposed to industrial arts concepts.

(d) The types of industrial arts activities engaged in by the students in the treatment group should be examined to see to what degree they are similar to activities which logically should reinforce mathematics.

(e) Mathematical concepts applied to the six areas of industrial arts are, for the most part, concrete. However, it is possible that the grade nine mathematics departmental examination placed more emphasis on testing students' abstract concepts. Thus, it is necessary to examine how many items assigned to each of the three objectives set up by the examination relate to concrete mathematical concepts. If very few of these items exist in each of the three objectives, then, use of other valid instruments of measuring students' mathematics achievement is recommended.

If the recommendations are carried out in future research, the effect of taking industrial arts on mathematics achievement will be understood in greater depth.

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APPENDIX A

EXAMPLES OF THE APPLICATION OF MATHEMATICAL CONCEPTS,
PRINCIPLES, THEORIES, AND/OR TECHNIQUES TO THE
SIX AREAS OF INDUSTRIAL ARTS

The application of mathematical concepts, principles, theories, and/or techniques to the six areas of industrial arts are exemplified as follows:

(a) Ceramics

Example I:

One of the students' experiences and activities in ceramics recommended by the Department of Education (1969, p. 31) in Edmonton was the use of common materials such as glazes.

According to California State Department of Education (1960, pp. 65-66), the application of the uses of glazes, mathematics involved, and its solution were described as follows:

Application

Test tiles fired, using a basic glaze composition of 3% bentonite and 97% frit, indicate crazing. The addition of china clay will correct existent crazing. Add different percentages of china clay to portions of basic glaze to correct. Use the following percents: 5,10,15,20, and 25.

Mathematics Involved

Percent, weight measurements

Solution: To each test mixture of 10 grams of basic glaze add specific amount of china clay. Add china clay: 0.5 gram (1/2 gram) = 5% of 10 grams, 1 gram = 10%, 1.5 grams = 15%, 2 grams = 20%, 2.5 grams = 25%. Identify each test tile. Fire test tiles. Comparison of test tiles show 15% china clay addition corrects crazing.

Example II:

Another of the students' experiences and activities in ceramics recommended by the Department of Education (1969, p. 45) in Edmonton was to understand the factors involved in finishing, for example, temperature.

According to California State Department of Education (1960, p. 62), the application of understanding temperature, mathematics involved, and its solution were described as follows:

Application

Find the temperature of an 06 pyrometric cone used in measuring kiln temperatures.

Mathematics Involved

Tables

Solution: Check a table for equivalent temperatures. Look up the cone number 06 and read temperature assigned.

(b) Graphic Arts

Example I:

One of the students' experiences and activities in graphic arts recommended by the Department of Education (1969, p. 74) in Edmonton was that, regarding the process camera simulation, it is necessary to set up a camera and to discuss the characteristics of ortho film.

According to California State Department of Education (1960, p. 53), the application of using a camera and of understanding the characteristics of ortho film, mathematics involved, and its solution were described as follows:

Application

The meter reading or calibration chart recommended 1 min. @ f/32 when photographing an 8 1/2" by 11" copy for same size reproduction. What shutter speeds should be used to (a) enlarge to 17" by 22"? (b) reduce to 2 5/6" by 3 2/3"? (c) use f/16 stop? (d) use f/45 stop?

Mathematics Involved

Ratios, tables

Solution: The process cameraman uses only time exposures. The exposure time depends upon lens stop, amount of enlargement or reduction, position and intensity of the lamps, the film, and the nature of the copy itself. Exposure meters or calibration charts are used in determining correct exposure time for a particular setting and film.

Tables with variations for enlargements and reductions provide changes in exposure time or in lens opening. (a) In 17" by 22" each dimension is 2 times the dimension of the copy. From tables, use 2 min. 15 sec. for 2X enlargement. (b) In $2\frac{5}{6}$ " by $3\frac{2}{3}$ ", each dimension is only $\frac{1}{3}$ of the dimension of the copy. From tables, use 27 sec., for $\frac{1}{3}$ X reduction. (c) To use next larger stop number halves the exposure time. f/16 is 2 stops larger than f/32. Use $\frac{1}{4}$ of 1 minute or 15 sec. exposure time. (d) To use next smaller stop number doubles the exposure time. f/45 is 1 stop smaller than f/32. Use 2 minutes exposure time.

Example II:

Another of the students' experiences and activities in graphic arts recommended by the Department of Education (1969, p. 74) in Edmonton was the film processing.

According to California State Department of Education (1960, p. 56) the application of film processing, mathematics involved, and its solution were described as follows:

Application

A film requires 8 minutes for development in 68° F. solution. How much time will be required for development at a temperature of 66° F.?

Mathematics Involved

Decimal fractions, percent

Solution: For high temperatures shorter times are required and for low temperatures longer times are necessary to produce the same contrast. The time for developing increases logarithmically as the temperature decreases linearly. This relationship varies with different developers. With semi-logarithmic graph paper and the development time at two temperatures, a straight line can be drawn for determining other time-temperature readings. Many mechanisms and devices for estimating time adjustments for temperature change have been suggested. One is an adjustment factor for each degree change from 68° F.; for 1° more than 68° F., reduce time by 4% of time allowed for 68° F.; for 2° more, reduce by 8%; for 3° more, reduce by 11%; for 4° more, reduce by 15%; and for 5° more, reduce by 18%. For -1° (less than 68° F.), increase time by 4% of time allowed for 68° F.; for -2°, increase by 9%; for -3°, increase by 15%; for -4°, increase by 21%; and for -5° increase by 27%. 66° F. requires an increase of time. 8 minutes increased by 9% of 8 min. = 8.72 or 8 min. 43 sec.

Example III:

Another of the students' experiences and activities in graphic arts recommended by the Department of Education (1969, p. 72) in Edmonton was to study the uses of inks.

According to California State Department of Education (1960, pp. 58-59), the application of the uses of inks,

mathematics involved, and its solution were described as follows:

Application

How much blue ink is required to print 2,500 four-page school programs, each page carrying a 6 by 9 type form of "catalog with cuts" variety and run on dull coated stock? ("Catalog with cuts" refers to a type form which includes text material and illustrations of medium weight. Dull coated stock refers to paper given a surface coating that is not glossy.)

Mathematics Involved

Areas, percent, ratios

Solution: $\text{Area} = 2500 \text{ copies} \times 4 \text{ pages/copy} \times (6 \times 9) \text{ sq. in./page} = 540,000 \text{ sq. in.}$ According to an "Ink Coverage Scale for Black Ink" dull coated stock requires 1.14 lb. of ink per million square inches when printing a "catalog with cuts" form. Therefore, $0.54 \text{ million sq. in.} \times 1.14 \text{ lbs./million sq. in.} = 0.6156$ or 0.62 lb. of black ink. Tabular values for additional amounts for colors or special processes show "for blue ink add 20% to the amount of black ink." $0.62 \text{ lb.} + 0.2 \times 0.62 \text{ lb.} = 0.744$ or $3/4 \text{ lb.}$

(c) Plastics

Example I:

One of the students' experiences and activities in

plastics recommended by the Department of Education (1969, p. 35) in Edmonton was to learn the use of tools related to the plastics areas.

According to California State Department of Education (1960, p. 63), the application of the use of tools related to the plastics areas, mathematics involved, and its solution were described as follows:

Application

Find the center of a round plastic lamp base 5" in diameter.

Mathematics Involved

Geometry of circles and rectangles, linear measurements.

Solution: Use Y-head from machinist combination square set. The rule on this set locates the diameter of the circle. The intersection of two diameters locates the center point. (Note: In the absence of the combination square set (Y-head), two chords of the circle can be used. The perpendicular bisector of each chord passes through the center of the circle. Perpendicular bisectors can be constructed with straight edge and compasses. After locating the center, a check should be made on the equality of radii by using compasses.)

Example II:

Another of the students' experiences and activities

in plastics recommended by the Department of Education (1969, p. 45) in Edmonton was to know finishing procedures such as sanding, polishing.

According to California State Department of Education (1960, p. 64), the application of knowing finishing procedures such as sanding, polishing, mathematics involved, and its solution were described as follows:

Application

How many pieces of Lucite plastic $1 \frac{1}{4}$ inches square by $\frac{3}{16}$ inches thickness would be needed to make a pair of salt and pepper shakers 2 inches in height. Allow $\frac{1}{16}$ inch for sanding and polishing each shaker.

Mathematics Involved

Common fractions, linear measurements

Solution: Divide height of shaker $2 \frac{1}{16}'' \div \frac{3}{16}''$, thickness of Lucite. $2 \frac{1}{16}'' \div \frac{3}{16}'' = \frac{33}{16} \times \frac{16}{3} = 11.11$ pieces would be required for one shaker and 22 pieces for the pair.

Example III:

Another of the students' experiences and activities in plastics recommended by the Department of Education (1969, p. 33) in Edmonton was to use basic system of metric measurement.

According to California State Department of

Education (1960, p.70), the application of using the basic system of metric measurement, mathematics involved, and its solution were described as follows:

Application

Give size of plastic material for cylindrical T.V. lamp shade having diameter 4", height 11".

Mathematics Involved

Areas, common fractions, geometry of right triangles and trapezoids, sketches, trigonometry

Solution: Surface of cylinder equals circumference multiplied by height, or $S = \pi dh$, $d = 4"$, $h = 11"$; $s = 3.14 \times 4 \times 11 = 138.16$ sq. in.

(d) Woodwork

Example I:

One of the students' experiences and activities in woodwork recommended by the Department of Education (1969, p. 34) in Edmonton was to examine all the cutting tools and machines in the area to determine the cutting principle that is most common.

According to California State Department of Education (1960, p. 99), the application of calculating the length of a band saw blade which is relating to the cutting principle of the cutting tools and machines, mathematics involved, and its solution were described as follows:

Application

A band saw has two 20" wheels spaced 40" between centers. Calculate the length of the saw blade.

Mathematics Involved

Geometry of circles, triangles, and rectangles;
linear measurements; ratios, square root

Solution: On an actual machine, this distance could be measured easily by using a flexible tape or a piece of string. In problems involving design and specifications of machinery, this distance must be computed. Since the wheels are of equal size, the blade will meet the wheels (tangent to the circles) at opposite ends of a diameter. Length of belt = 2 X distance between centers + circumference of one wheel = $2 \times 40" + 20" \times \pi = 80" + 62.8" =$ (approximately) 142.8 inches.

Example II:

Another of the students' experiences and activities in woodwork recommended by the Department of Education (1969, p. 38) in Edmonton was to use the cutting machines that remove material, for example, lathe.

According to California State Department of Education (1960, pp. 90-91), the application of using the cutting machines that remove material, for example, lathe, mathematics involved, and its solution were described as follows:

Application

A piece of stock turned on the lathe is calipered at $3 \frac{3}{4}$ " diameter. Calculate how much material must be cut to have a finished diameter of $3 \frac{1}{8}$ ".

Mathematics Involved

Linear measurements

Solution: Amount to be cut = $(3 \frac{3}{4}" - 3 \frac{1}{8}") \div 2 = 5/16"$. (Note: Diameter decreases double the amount of the cut.)

Example III

Another of the students' experiences and activities in woodwork recommended by the Department of Education (1969, p. 44) in Edmonton was to discuss preparation for finishing including painting with a brush.

According to California State Department of Education (1960, p. 96), the application of computing proportionate amounts of finishing materials which was relating to the preparation for finishing including painting with a brush, mathematics involved, and its solution were described as follows:

Application

Find the amounts of shellac and alcohol needed to finish a project with a wash coat and two finish coats. Each coat requires approximately $1/2$ gallon of finish. The wash coat contains 1 part of shellac to 7 parts of alcohol. The first finish coat contains the ratio of shellac to alcohol of 1 to 1, and the second finish coat 4 to 3. Use the closest appropriate container measure.

Mathematics Involved

Common fractions, liquid measurements, ratios

Solution: 1 part of shellac to 7 parts of alcohol
 = 1 part of shellac to 8 parts of mixutre. $\frac{1}{8} \times \frac{1}{2}$ gal.
 = $\frac{1}{8} \times 4$ pt. = $\frac{1}{2}$ pt. shellac. 4 pt. - $\frac{1}{2}$ pt. = $3 \frac{1}{2}$
 pt. alcohol for wash coat. First finish coat: $\frac{1}{2} \times \frac{1}{2}$
 gal. = 2 pt. shellac. 4 pt. - 2 pt. = 2 pt. alcohol.
 Second finish coat: $\frac{4}{7} \times \frac{1}{2}$ gal. = $2 \frac{2}{7}$ or (approximately)
 $2 \frac{1}{4}$ pt. shellac. 4 pt. - $2 \frac{1}{4}$ pt. = $1 \frac{3}{4}$ pt. alcohol.

(e) Electricity

One of the students' experiences and activities in electricity recommended by the Department of Education (1969, p. 56) in Edmonton was to wire batteries in series and parallel and to compare voltages.

According to California State Department of Education (1960, p. 34), the application of wiring batteries in series and parallel and of comparing voltages, mathematics involved, and its solution were described as follows:

Example I:

Application

Find the total voltage of 3 dry cells connected in series.

Mathematics Involved

Common fractions

Solution: Add volts, $1 \frac{1}{2} + 1 \frac{1}{2} + 1 \frac{1}{2} = 4 \frac{1}{2}$ volts, or multiply, $3 \times 1 \frac{1}{2} \text{ volts} = 4 \frac{1}{2} \text{ volts}$.

Example II:

Application

Find the total voltage of 3 dry cells connected in parallel.

Mathematics Involved

Fundamental operations

Solution: The voltage of a number of cells connected in parallel is assumed to be the same as the voltage of one cell. The voltage of this connection of cells is $1 \frac{1}{2}$ volts.

Example III:

Another of the students' experiences and activities in electricity recommended by the Department of Education (1969, p. 57) in Edmonton was to develop experiences to illustrate Ohm's Law.

According to California State Department of Education (1960, p. 36), the application of calculating current in a simple, direct current circuit when voltage and resistance are known, which was relating to Ohm's Law, mathe-

matics involved, and its solution were described as follows:

Application

An electric bell has a resistance of 45 ohms and is supplied with $4 \frac{1}{2}$ volts. How much current will be drawn by this bell?

Mathematics Involved

Common fractions, formulas

Solution: $E = IR$; $E = 4 \frac{1}{2}$, $R = 45$; $4 \frac{1}{2} = 45I$,
 $I = \frac{4 \frac{1}{2}}{45} = \frac{1}{10}$ amp. or .1 amp. (.1 ampere is the same as 100 milliamperes.)

(f) Metalwork

Example I:

One of the students' experiences and activities in metalwork recommended by the Department of Education (1969, p. 36) in Edmonton was to be familiar with the adjustable parts and the way in which adjustments, speed . . . affect the cutting process.

According to California State Department of Education (1960, p. 79), the application of determining cutting speeds, mathematics involved, and its solution were described as follows:

Application

Compute cutting speed of a $\frac{1}{2}$ " carbon drill,

rotating at 2240 r.p.m., in mild steel.

Mathematics Involved

Formulas, tables

Solution: Visualize a point on the circumference of a drill. With every revolution the point moves a distance equivalent to the circumference. The formula is

$S = \frac{\text{r.p.m.} \times d}{4}$, S is the cutting speed in feet per minute and d is the diameter of the drill. Substitute the known values, the cutting speed is 280 feet per minute.

Example II:

Another of the students' experiences and activities in metalwork recommended by the Department of Education (1969, p. 34) in Edmonton was to learn the proper use of tools used in the metal area.

According to California State Department of Education (1960, p. 75), the application of using a tool-micro-meter to find the thickness of sheet steel, mathematics involved, and its solution were described as follows:

Application

A sheet metal container with a hemmed edge is to be duplicated, using the same gauge of material. Measure the thickness of the metal.

Mathematics Involved

Linear measurements

Solution: Set the micrometer on a flat section of the material. Count the number of major divisions entirely visible on the sleeve. Multiply this by 0.1. Count the additional minor divisions entirely visible on the sleeve. Multiply this by .025. Read the number of divisions on the thimble to which the thimble has been turned. Multiply this by .001. Add the products resulting from the three multiplications.

Example III:

Another of the students' experiences and activities in metalwork recommended by the Department of Education (1969, p. 40) in Edmonton was to understand the process of casting and to cast a product using a material such as aluminum.

According to California State Department of Education (1960, pp. 81-82), the application of determining the percent of shrinkage in a casting and of casting a product using a metal such as aluminum, mathematics involved, and its solution were described as follows:

Application

The pattern for an aluminum plaque is $1\frac{1}{2}$ " X $2\frac{7}{8}$ " X 13". The casting shrinks $\frac{3}{32}$ " per linear foot in cooling.

(a) What is the percent of shrinkage allowance required.

(b) Find the over-all dimensions of the completed pattern when measured with a standard rule.

Mathematics Involved

Common fractions, decimal fractions, percent

Solution: $3/32$ " shrinkage per foot = $\frac{.0937}{12}$ or .78 percent, in percent allowance for shrinkage. (b) .78% shrinkage allowance indicates that .0078 inch are lost for each inch. The over-all dimensions of the completed pattern require an additional allowance of .0078" for every inch. $1/2$ " \times .0078 = .0039", $2\ 7/8$ " \times .0078 = .0224", $13 \times$.0078 = .1014". The completed pattern must be $1/2$ " by $2\ 29/32$ " by $13\ 7/64$ ".

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